DOCUMENT RESUME

ED 045 678 | 24 | TE 002 191

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TITLE Studies in Convergent Communication: 2. A Measure of Communication Accuracy.
INSTITUTION Johns Hopkins Univ., Baltimore, Md. Center for the Study of Social Organization of Schools.
SPONS AGENCY Office of Education (DHEW), Washington, D.C. Bureau of Research.
REPORT NO R-91
BUREAU NO BR-6-1610-04
PUB DATE Nov 70
GRANT OEG-2-7-061610-0207
NOTE 55p.

EDRS PRICE EDRS Price MF-$0.25 HC-$2.85
DESCRIPTORS *Communication (Thought Transfer), Communication Skills, *Culturally Disadvantaged, Disadvantaged Youth, Intelligence Level, *Language Arts, *Problem Solving, Racial Differences, Scientific Methodology, Sex (Characteristics), Social Status, Socioeconomic Status, Success Factors, Teaching Techniques, Verbal Communication

ABSTRACT

A type of problem-solving communication was defined in which communication accuracy was expected to be facilitated by common factors. Three tasks were developed which represented this class of communications and permitted the assessment of communication accuracy. Dyads (48) of grade 5 students--six of boys and six of girls from four population groups: Negro, white, low and middle SES--were observed performing the tasks. The accuracy scores achieved by pairs were consistent across the three tasks. The K-R 20 estimate of internal consistency was .72. Three components of accurate communication were identified: (1) orientation of one member to the other's point of view, (2) communication of essential information, (3) verification of the problem's solution. Measures for describing the adequacy of dyads' performance of these components were derived and correlated with communication accuracy. Each component correlated significantly with accuracy and the three components combined accounted for 44% of the observed variance in accuracy scores. It was also found that accuracy is related to IQ and SES, but not to sex or race. These results can be a step in identifying components which could be taught to help students communicate more accurately. (See also TE 002 138.) (Author/DD)

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ED045678

# STUDIES IN CONVERGENT COMMUNICATION:

# II. A MEASURE OF COMMUNICATION ACCURACY

Report No. 91

Grant No. OEG-2-7-06160

BR 61610-04

Thelma Baldwin and Catherine Garvey

November, 1970

TE002191

Published by the Center for Social Organization of Schools, supported in part as a research and development center by funds from the United States Office of Education, Department of Health, Education, and Welfare. The opinions expressed in this publication do not necessarily reflect the position or policy of the Office of Education, and no official endorsement by the Office of Education should be inferred.

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Baltimore, Maryland

Table of Contents


| | |
|---|---|
| Acknowledgements | i |
| Abstract | ii |
| Preface | iii |
| Introduction | 1 |
| Method | 7 |
| Results and Discussion | 18 |
| Summary and Conclusions | 32 |
| References | 34 |
| Appendix A - Social Status Questionnaires | 36 |
| Appendix B - Experimental Tasks | 38 |

Acknowledgements

The authors gratefully acknowledge the cooperation of principals, teachers and staff members of the elementary schools and state colleges in which the data for this study were collected. Deserving of special, though necessarily anonymous, recognition are those students who willingly and enthusiastically carried out the problem-solving tasks.

The authors also wish to thank Dr. Paul T. McFarlane for his assistance in the development of the first task and Mrs. Leslie Schnuelle for her careful work in the analysis of the data. Thanks are also extended to Professor Julian Stanley for his assistance with statistical problems.

## Abstract

A type of problem-solving communication is defined in which communication accuracy is expected to be facilitated by common factors. Forty-three pairs of fifth-grade children were observed performing three tasks which represent the defined type of communication. As predicted, the accuracy scores achieved by pairs in these communications were consistent across the three tasks. The K-R 20 estimate of internal consistency was .72. Three components of accurate communication were identified and measures for describing the adequacy of dyads' performance of these components were derived and correlated with communication accuracy. Each component correlated significantly with accuracy and the three components combined accounted for 44% of the observed variance in accuracy scores. These results were interpreted as an initial step in identifying communication components which could be taught in language arts curriculum to help students communicate more accurately.

The observed relationship of SES, race, sex and IQ characteristics of communicators to communication accuracy is also presented.

## Preface

This paper is the second of a series of three reports on a project of the Language and Communication Program. The purpose of the project is to study how children exchange information in problem-solving situations. Two principal areas of research are (1) the study of the speech behavior in these communication situations and (2) the search for determinants of accuracy in carrying out the problem-solving tasks. Underlying both areas of research is the attempt to delimit a type of communication situation which (1) would show consistent linguistic and interactional characteristics and (2) would serve as a framework in which behaviors and factors contributing to accurate solutions could be identified. Accordingly, three tasks representing the defined type of communication were developed and were administered to children and to adults.

The first report dealt with the problems of describing the linguistic behavior in the communications and included a coding manual developed for use in subsequent studies. Evidence of inter-judge agreement in the use of the coding system was also presented. The present report describes the tasks designed to elicit problem-solving behavior, reports on their adequacy as a measure of communication accuracy and identifies components of accurate communications. The role of speaker characteristics in the prediction of communication accuracy is also examined. The third report will present further results of comparisons of child and adult communications, including structural characteristics of the communications as well as features of strategy related to the principal performance measures.

## Introduction

Educators have assumed there are oral language skills which facilitate effective communication. Text books in language arts, for example, include lessons on "taking part in conversations," "using a telephone," or "making introductions" - lessons which instruct students to listen politely, speak clearly, and take turns talking (see, for example, the widely used text by Sterling et al., 1957). The content of these lessons demonstrates educators' concern with one aspect of effective communication, i.e., the use of accepted prescriptions of polite conversation. Although another important aspect of effective communication is the accurate exchange of information, lessons specifically designed to facilitate accuracy are not included in the language arts curriculum. There are seemingly relevant lessons; for example, Sartain's text, English is Our Language, includes a unit entitled "Communicating Ideas" in which there is a lesson on conversation. This lesson instructs students to listen carefully, answer questions, tell something others enjoy hearing, refrain from speaking when another is speaking, and speak in a clear voice and a friendly way. Unfortunately, there is not even sound evidence that these behaviors are associated with more accurate communication. Moreover, there is no evidence that merely telling students to do such things affects their ability to communicate accurately.

Psychologists have also been interested in factors related to effective communication and their work has been much more concerned with accurate communication. Mehrabian and Reed (1968) have proposed a model in which communication accuracy is determined by five sets of independent variables: attributes of the communicator, of the addressee, of the

channel, of the communication and of the referent. They provide an extensive review of research which demonstrates various relationships between these variables and communication accuracy. Flavell and his associates (1968) provide another review of research related to the development of role-taking ability and communication skill. Taken together this body of research implies that psychologists, like educators, have assumed that there are characteristics of individuals and of communications which affect the accuracy of communication. It is tempting to assume that the findings and conceptualizations of this research could be used to identify a set of communication skills which have been shown to facilitate communication accuracy, and which, therefore, could be used to construct reasonable objectives for language arts instruction.

Unfortunately, the relationship of the earlier findings to the demands of a language arts curriculum is superficial. Educators are concerned with effective communication in complex, natural situations; that is, they are concerned with identifying and instructing skills which are related to communication accuracy in a broad category of communication tasks, a category which has relevance to naturally occurring communication situations.

Psychologists, however, have paid little attention to differences and similarities in the communication situations where the determinants of accurate communication have been studied. The Mehrabian and Reed review, for example, implies that there is a construct of communication accuracy which can be observed in a number of different experimental situations and measured with a variety of operations. Communication accuracy is defined as "the degree of correspondence between the referents decoded, or inferred, from a set of communication behaviors by an addressee

and the referents encoded, or represented, in those communication behaviors by the communicator" (Mehrabian & Reed, 1968: 365). It is assumed that this correspondence determines success in such diverse operational definitions of communication accuracy as the correct identification of a design, face or abstract shape from an array of similar stimuli; the efficient solution of a game of Password; and good performance on examinations testing information acquisition or attitude change. Each investigation typically uses one such operational definition of communication accuracy, and the extent to which these operations represent a larger construct of communication accuracy has not been questioned. The investigations of Flavell and his associates (1968) are an exception in that they used 16 different and ingenious tasks, each supposedly assessing somewhat different aspects of effective communication. It is surprising to find, however, that they examined the relationship of performance on each task with age and yet did not consider the overall relationships among the tasks.

Given the tremendous variation in communication situations and in the demands they place on the communicators (c.f. Cazden, in press), it would seem naïve to assimilate the findings from the diverse experimental situations into a set of communication skills which would be expected to significantly facilitate communication accuracy in general.

This research, therefore, is an attempt to modify the approach to the study of communication accuracy by delimiting the type of communications in which it is observed. It is expected that in a defined class of communication, the behaviors contributing to accuracy will occur more consistently and, therefore, the components of accuracy can be more readily identified. More specifically the research is an attempt to (1) specify

a class of communications where communication accuracy could be considered a general phenomenon, (2) develop communication tasks which represent this type of communication and which permit an assessment of accuracy and (3) show that accuracy on all of the tasks is related and that it can be accounted for by hypothesized components of accurate communication.

The specified class of communication has been presented in a previous report and defined as convergent communication (Garvey & Baldwin, 1970). This is a type of verbal problem-solving communication in which two persons cooperatively exchange information in order to reach an explicitly stated goal. It is further specified that the two persons together have sufficient information to solve a given problem, but neither person can solve it alone, and therefore cooperation and exchange is necessary in order to reach a solution. This convergence of information into a task solution accounts for the designation convergent communication.

This type of communication would be expected to occur in many natural speech situations, particularly in consultation situations. For example, when someone asks another how to get to a certain address, or how to treat an illness, or how to solve an arithmetic problem, there are two persons who, together, have sufficient information to solve a problem, and they exchange that information in order to reach a successful solution.

A further characteristic of these communications is that there is a distinction between the two participants. One is a Knower who is cognizant of the form of the final solution. The other is the Doer who is aware of the problem and has the responsibility of executing its solution. For another example, in the situation where a student and a counselor talk together to arrange an acceptable academic schedule, the counselor (Knower) is cognizant of course prerequisites, degree requirements and

courses offered. The student (Doer) is aware of his interests, career ambitions and previously completed course work. The two cooperate to reach a solution which the student executes, i.e., writes down and takes to the registrar.

There are several reasons from several sources for expecting that accuracy in representative convergent communication tasks would be interrelated. First, if Mehrabian and Reed are correct, the skills of individual participants - such as encoding, decoding, and using mutually understood referents (identified by Johnson & Gross, 1968) - which have been related to accuracy in simpler tasks would be expected to have some small relationship to accuracy in these communication tasks as well, and produce some consistency of performance. Second, other researchers have reported characteristic features of problem-solving communications which make them distinct from other forms of conversation (Cherry, 1957; Garvey & Baldwin, 1970; McGuire & Lorch, 1968). Features such as unique rules for language conduct, for information coding and for sentence generation (McGuire & Lorch, 1968) could be expected to interact with the capabilities of communicators and affect the accuracy of all problem-solving communications similarly for any pair of communicators.

The third line of reasoning comes from investigations of individual problem-solving. Most of the investigators of human problem-solving agree that it is a process which includes certain stages. "These [stages] have been variously described, but perhaps they can be summarized as follows: (1) statement of the problem; (2) further defining the problem, by defining essential features; (3) searching for and formulating hypotheses; (4) verifying the solution" (Gagne´, 1966: 138). Like individual problem-solving, problem-solving communications could also be

expected to include stages or components, and the accuracy of final solutions would depend on the successful performance of the components. The stages or components summarized by Gagne´ would have to be modified somewhat in order to fit a two-person problem-solving situation. The analysis and speculation conducted here resulted in the following five components: (1) definition of the general problem, (2) orientation of Knower to Doer's situation, (3) communication of essential information, (4) synthesis of information and formulation of solutions, and (5) verification of the solution.

Of these, components 2, 3 and 5 would have to occur overtly in the defined type of communication in order to reach an accurate solution. The first component would often be completed before conversation begins, i.e., it is the recognition of the general problem that instigates the conversation. The fourth component, "the systhesis of information and the formulation of solutions," is a cognitive process which would be performed implicitly by the Doer in these situations and would not necessarily be represented in the conversation. Thus there are three components proposed which a successful convergent communication should include; the Knower must be oriented to the Doer's situation, the essential information must be identified and communicated, and the Doer's solution must be verified. The accuracy of the communications would be largely determined by a dyad's success in performing these common components.

This research reports the observations made while children and adults performed three convergent communication tasks. The consistency of performance in the three tasks is examined; an attempt is made to identify the three components mentioned above; and the relationship of

speakers' individual characteristics to differences in communication accuracy is also presented.

## Method

### Subjects

Children. A sample of 96 fifth-grade children was selected so that it included Negro and white children from low and middle socioeconomic status (SES) backgrounds. Six dyads of girls and six dyads of boys were selected from each of the four population groups (Negro, white; low and middle SES). The selection procedure consisted of choosing four neighborhoods in Baltimore which, according to census tract data and city surveys, represented the four populations. Letter-questionnaires were sent home to the parents of the fifth-grade students in the schools serving those neighborhoods, and the sample was selected from those students (approximately 77%) who returned the questionnaires. (A copy of the questionnaire is included in Appendix A.)

Information about the occupation of the head-of-household was obtained from the questionnaires and rated according to the Hollingshead occupational scale (Hollingshead & Redlich, 1958). The scale includes seven levels. If the head-of-house was unemployed or in an occupation rated at one of the three bottom levels (skilled worker, semi-skilled worker or unskilled worker) the S was designated as low SES. If the occupation was rated above that (owners of businesses, executives, managers, professional workers), S was designated as middle SES. When both parents were employed, the occupation giving the higher Hollingshead rating was used.

As a result of this sampling procedure, the Ss designated low SES

Negro were Negro fifth graders who lived in a largely black, urban neighborhood, which was in the highest quarter of the 1960 city ratings of unemployment, poverty and percentage of adults below an eighth-grade education level. From the letter-questionnaires it was determined that the heads-of-households for Ss in this group were skilled, semi-skilled or unskiller or unemployed workers. The questionnaires also showed that the average number living in a household was 6.46 and fathers were living in only 58% of the homes. The low SES white Ss were fifth graders from a largely white urban neighborhood, also in the highest quarter of the 1960 city ratings of unemployment, poverty and percentage of adults with less than eighth-grade education level. The heads-of-households for Ss in this group were also employed as skilled, semi-skilled, unskilled, or unemployed workers. The white low SES sample differed from the Negro low SES, however, in that the average number living in a household was less (5.33) and fathers were living in nearly all (91%) of the homes. Unfortunately, this difference in the living situation of the subjects in the two low SES groups is probably a significant one. Both the presence of a father in the home and the number of people living in a single household are considered indices of social class. Our sampling procedure which matched the groups on level of occupation did not successfully control for these other factors. Thus on some indices of social class the sample of Negro low SES subjects is lower than the sample of white low SES subjects.

The Negro and white middle SES groups came from neighborhoods located within, but near the edge of, the Baltimore City limits. Both neighborhoods were in the lowest quarter of the 1960 ratings of unemployment, poverty and percentage of adults below eighth-grade education level. The heads-of-households for all Ss in these groups were employed

in professional or managerial positions or were owners of their own businesses. For both the Negro and white groups the average number living in a household was 4.75, and fathers were living in nearly all of the homes (92% and 96% for Negro and white respectively). The middle SES Negro Ss came from a largely Negro neighborhood; the middle SES white Ss came from a largely white neighborhood.

Since the students from the four population groups (i.e., low SES Negro, low SES white, middle SES Negro, middle SES white) came from four different schools, school differences are confounded with social and racial differences. Thus, characteristics of the fifth grades in the four schools, which are presented in Table 1, further describe differences in the social contexts of the four population groups observed.

Table 1

Characteristics of Schools Representing the Four Social Groups

| School Population | | School Characteristics | | | | | |
|---|---|---|---|---|---|---|---|
| | | Iowa Test of Basic Skills[a] | Racial Composition | | Enrollment ÷ Bldg. Capacity | Pupils Per Teacher | Pupils Per Aide |
| | | | % non-white | % white | | | |
| Low SES | Negro | 4.1 | 100 | 0 | 1.16 | 35 | 39 |
| | White | 4.1 | 0 | 100 | .96 | 27 | 232 |
| Middle SES | Negro | 4.9 | 100 | 0 | 1.11 | 34 | 125 |
| | White | 5.9 | 10 | 90 | 1.05 | 32 | 135 |

[a]These scores are the median grade levels obtained by the fifth grade students in each school.

The population of students considered for selection was further restricted by considering only those students who were of normal age-grade placement (approximately ten years old) and whose Kuhlmann-Anderson IQ scores were within a normal range (85-115). The twelve boys and twelve girls from each school were selected randomly from the fifth graders who met all criteria of selection for each of the four population groups.

The twelve students within each sex, race and SES group of the sample were randomly assigned to dyads. Thus, the communication behavior observed occurred between randomly selected classmates of the same sex and race, and approximately the same age and socioeconomic status. This arrangement of Ss in dyads of peers was used in order to avoid factors, such as differing status of the two participants or possible cultural differences in the use of referents and communication styles, which would be expected to inhibit or restrict communication factors.

The observation of these Ss performing the first task was made in October, 1969. Two months later, a follow-up observation of two additional tasks was made. Some of the dyads in the original sample were lost during this time because of prolonged illness or the relocation of families outside the school neighborhood. It was necessary, therefore, to select five substitute dyads who met the criteria used to select the original sample (i.e., residence, occupation of head-of-house, race, age, sex and IQ). In analyses of performance within any one of the tasks, therefore, 48 dyads were used. In analyses which were used to examine relationahips between the tasks, however, only 43 dyads could be used.

Adults. A sample of 48 adults was also observed performing the three tasks. Adult volunteers from teacher training programs at both

a predominantly Negro state college and a predominantly white state college were obtained by posting sign-up sheets offering $3.00 for participation. From the lists of volunteers 12 Negro women, 12 Negro men, 12 white women and 12 white men were selected. Subjects within these race and sex groups were assigned at random to time-schedule positions which did not conflict with their class schedules. Therefore, members of adult dyads were also of the same sex and same race. The SES characteristics of the adult Negro and white samples are presented in Table 2.

TABLE 2

Socioeconomic Characteristics of Adult Negro and White Samples

| Population | Mean no. Persons per Household | Mean occ. level[a] | Father's level of Educ.(yrs.) | Mother's level of Educ.(yrs.) |
|---|---|---|---|---|
| Negro | 6.08 | 4.21 | 12.57 | 13.08 |
| White | 4.46 | 3.92 | 11.74 | 11.29 |

[a]Mean occupation level is based on the Hollingshead occupational scale (Hollingshead & Redlich, 1958).

Experimental Tasks

In all three tasks a visual barrier was placed between the two persons in the dyad and they were asked to complete a task. Instructions stated the goals of the tasks, but no restrictions were placed on the amount or content of the verbal exchanges the dyad used to

reach those goals. (The task materials and instructions are included in Appendix B.)

Task I: Picture identification. One member of the dyad was given a card containing a picture of an imaginary creature. The other person, seated on the opposite side of the partition, was given a page containing seven pictures. A subtask was terminated when the person with the group of pictures turned to the experimenter and pointed out the creature on his page which he said matched his partner's picture. Ten different subtasks were presented consecutively, alternating, each time, the recipients of the single picture and the group of seven pictures.

The stimulus materials used in Task I consisted of ten sets of pictures. Each set contained a 3" x 5" index card with a single picture on it and an 8 1/2" x 11" page with seven different pictures on it. Only one of the seven pictures was exactly like the single picture. The pictures in each set consisted of seven variations of one figure which had four attributes that could be varied independently. For example, the first set of pictures presented in Appendix B, page 40, shows a hat which has a rounded or peaked crown, a broad or narrow brim with wide or narrow stripes and a full or tipped feather. A random process was used to select the particular combination of four attributes to be included in the single picture. In the page of hat pictures, the hat in position six, which has the peaked crown, the narrow brim with narrow stripes and a full feather, is exactly like the single picture. In a similar manner, a random process was used to select two combinations of the four attributes which differed from the single picture on only one dimension, two combinations which differed from the single picture on two dimensions and two

combinations which differed on three dimensions. These six combinations plus the combination represented in the single picture were randomly assigned to positions on the 8 1/2" x 11" sheet. The complete set of ten pictures is presented in Appendix B. The dyad's choice was scored for accuracy by counting the number of distinguishing attributes the chosen and the correct figure had in common. Thus, the accuracy score for one task could range from 1 (only one distinguishing attribute in common) to 4 (completely correct).

Task II: Model building. The task consisted of building four models of molecules; $NH_3$, $C_3H_6$, $C_4H_{10}$ and $C_2H_5O_2N$. One dyad member was given a completed model and the other was given a box of pieces including various colored balls, sticks of two different lengths and springs. (The task was described to the subjects as a model building task, and the names of the molecules were not mentioned.) The models were presented in the order described above and each subtask ended when the dyad members agreed that the constructed model matched the original. At the end of each subtask, the experimenter collected the models and without giving verbal feedback or permitting the dyad members to see one another's models, he (she) presented the next model. Members of the dyad alternated in receiving the completed model.

A variation was introduced in the procedure for the third and fourth models. When building these two, considerably more complex models, a completed portion of the model was included in the box of pieces. Therefore, the task for the third and fourth models was to complete the partially constructed model. Illustrations of the four models used in the task are shown in Appendix B, page 47. The accuracy was assessed

according to the number and color of balls included, and the number and shape of the bonds in the completed model.

Task III: Map tracing. This task involved tracing a path on a picture map from one landmark to another, i.e., from home to school or from school to the ball park. Both members of the dyad were given copies of the same picture map. One member, however, had the correct path traced in red on his map. His partner was given an unmarked map and a colored pencil. The task involved the communication of the correct path so that the member with the unmarked map and pencil could draw the correct route to the prescribed destination. Two map problems were included in the task and the dyad members alternated giving and following directions. No experimenter feedback was provided. Accuracy was assessed by counting the number of correct corners included in the drawn path. (Copies of the maps and the correct routes are included in Appendix B.)

Summary. Although the three tasks involve solving three different problems, there are similarities in the communication problems which, we suggest, place similar demands on the communication skills of the participants. In all three tasks the dyad must verbally exchange information in order to reach a goal which is clearly stated in the task instructions. In each task there is a Doer who must execute a solution and a Knower who has information the Doer needs in order to execute the solution correctly. In all three tasks, the accuracy of the solution, executed by the Doer, can be observed and assessed independently of the verbal exchanges in the communication.

## Procedure

General Description. Tasks were administered to one dyad at a time. A male experimenter worked with male dyads and a female experimenter worked with female dyads. When the two subjects entered the experimental room, they were seated at a table with a screen between them, preventing any non-verbal communication. An Electro-Voice microphone was placed on the screen separating the subjects and a Uher (Model 4000) tape recorder was used to record communication throughout the experimental procedure.

At the beginning of each of the three tasks the experimenter presented standard instructions to the dyad. All three sets of instructions stressed the fact that the dyad was to act together as a team and included the words, "You can both ask each other any questions you want to and you can take as long as you want to. The only thing you can't do is look at each other's pictures (models or maps)." (Complete instructions are included in Appendix B.)

Procedural questions were answered where possible by repeating phrases in the standard instructions. After the instructions had been given, the experimenter distributed the materials for the first subtask and withdrew from the interaction until he presented the next subtask. The subtasks were presented so that Doer-Knower responsibilities alternated between the two members of the dyad. The Knower in one subtask became the Doer in the next and so on.

The dyad conversed until they indicated to the experimenter that they had reached a solution and were ready for the next problem. The dyads' choices, models and maps were recorded or collected and scored

for accuracy at a later time. Dyads were not given feedback from the experimenter concerning success or failure on any of the tasks.

Procedures for children. The three tasks were administered to children in two experimental sessions, the picture identification task in October, 1969, and the other two tasks in December, 1969. For both sessions children came from their classrooms, two at a time, to a small room located in their school building. They were greeted by an experimenter and seated at the table on either side of the visual barrier.

The first session began with a warm-up procedure consisting of two rounds of "Password." The experimenter then used standard instructions to present the picture identification task. Ten subtasks were presented in a fixed order. Each subtask ended when the person with the set of pictures indicated his choice, and the session ended after the tenth subtask.

In the second session the warm-up procedure was omitted and the standard instructions for the model task were given. In presenting this task, the experimenter showed both subjects the box of balls, sticks and springs, and then demonstrated how models were built by assembling and disassembling two samples, NaCl and $CH_4$. The molecular names of these models were not included in the instructions. The model building task was then administered. Each subtask ended when the person with the box of pieces handed an assembled model to the experimenter.

After the completion of the four model subtasks the standard instructions for the map tracing task were given, and the task was administered in the standard procedure. A subtask was completed when

the person drawing the route on the map handed his map to the experimenter. The second session ended when the second map was completed.

Procedures for adults. A few changes were made in the procedures and instructions used with adults. Adult subjects came to a designated room on their campus at an appointed time. The experimental setting was the same as it had been for the children. All three tasks, however, were administered to them in a single, one-hour session. Subjects were told that they were to perform three problem-solving tasks that had been administered earlier to school children. The language in the standard instructions used to present the tasks was made more suitable for adults but the general procedures and task requirements were not changed. For adults between the picture identification task and the model building task, a break was scheduled in the procedure. During the break subjects filled out a "Family History Questionnaire" which requested socioeconomic information. Additional time was used to administer a "Special Attitude Questionnaire" which measures empathy (Hogan, 1969). Copies of the standard instructions and the "Family History Questionnaire" are included in the appendices.

## Data Preparation

The accuracy scores for each dyad on each task were tabulated from the experimenters' records of the chosen pictures, the constructed models and the drawn maps. The accuracy scores, then, are based on all performed tasks.

Other scores, however, such as the dyad's total verbal output (TVO), were derived from transcripts of the communications. Since the cost of

transcribing was considerable, only a sample of the communication tasks was used. The sample of transcribed communications includes all ten subtasks of Task I, the third and fourth subtasks of Task II and the second subtask of Task III. For the adults, the first subtask of Task III was also transcribed.

Conventions were established for the transcribers so that word counts would not be affected by various transcribing styles. Conventions were established to indicate interruptions, pauses, unintelligible material and several gestures of assent, disagreement or hesitation. Standard English spelling was used throughout except for the merger of "to" and "of" with the preceding word, e.g., "gonna," "kinda." A linguist periodically checked the transcriptions for consistency with the established conventions. (Further detail about the transcribing procedures is presented in Garvey & Baldwin, 1970.)

## Results and Discussion

The results will be presented and discussed in three sections. The first reports the observed communication accuracy scores for each task and examines the hypothesized consistency of these scores across the three tasks. The second presents an analysis of the communications and identifies components of accurate communications. The third relates the differences in the accuracy scores and in the identified components to characteristics of the speakers.

Observed Communication Accuracy

Although the tasks were designed to measure children's communication accuracy, the means and standard deviations of the raw accuracy scores for both adults and children are presented in Table 3. As expected nearly all adult dyads produced completely accurate solutions. There is some variance in the accuracy of adult performance on the model building task, but nevertheless, the tasks, as a whole, are too easy to be used to measure adult communication accuracy. Thus, the adult data is presented here only for purposes of comparison to children's performance. It is not used in the analysis of the consistency of communication accuracy in convergent communication tasks.

TABLE 3

Means and Standard Deviations

of Raw Accuracy Scores

| Task | Possible Maximum Score | Children | | Adults | |
|---|---|---|---|---|---|
| | | $\bar{x}$ | s.d. | $\bar{x}$ | s.d. |
| Picture Identification | 40.00 | 33.60 | 2.81 | 38.54 | 1.31 |
| Model Building | 180.00 | 159.45 | 20.55 | 175.33 | 4.67 |
| Map Tracing | 36.00 | 18.51 | 11.55 | 35.31 | 1.95 |

The children's scores do represent a range of communication accuracy. The picture identification was, perhaps, too easy for the fifth-grade students. Technically, the scores could range from 10 to 40; thus, the children's mean of 33.60 is high. Likewise, because of the restriction

on the top of the scale, the distribution of scores has small variance. In comparison with the picture task the model building and map tracing tasks were more difficult for the children. The large standard deviations of the raw scores on these two tasks can be explained by the fact that student errors are likely to be correlated. Missing one corner on a map tracing task, for example, is apt to result in missing several others. Thus the distribution of subtask scores is apt to include extremely high and low scores and, as a result, the variance would be large.

In order to examine the predicted inter-task consistency in accuracy scores, K-R 20 reliability coefficients were first computed for the subtask accuracy scores within each task. These estimates of inter-subtask consistency were as follows: picture identification, .22; model building, .80; map tracing, .85. These estimates, however, may not be particularly good tests of the hypothesized relationship among performances on convergent communication tasks. Each task consists of a series of very similar subtasks, and it would be expected that learning would take place at the beginning of the series which would specifically facilitate accuracy on the rest of the series. Therefore, the series of tasks would not be completely homogeneous and inconsistent performance would result.

The estimate of inter-subtask reliability for the picture identification is further affected by the fact that the tasks were easy for fifth graders and the variance of the total scores was low.

In light of these problems with subtask accuracy scores, it was decided that a better test of the predicted inter-task consistency of communication accuracy would consider the relationship among the total scores for each task. As expected the correlations among the three tasks were significantly positive: picture identification and model building,

$r = .41$ ($p < .01$); picture identification and map tracing, $r = .53$ ($p < .01$); model building and map tracing, $r = .48$ ($p < .01$). In order to estimate what the relationships among the accuracy measures might have been without errors of measurement, an attempt was made to use the previously computed estimates of inter-subtask reliability to correct these correlations for attenuation. The results, however, were unsatisfactory. Two of the three corrected correlations were greater than one, indicating that the K-R 20 coefficients grossly underestimated the reliability coefficients for the subtasks.

Since accuracy on the three tasks was significantly related, it was decided that the three total scores could be combined into one measure of communication accuracy. In order to weight the tasks equally in the combined score, the accuracy scores for each task were transformed to standard scores and a constant of ten added. Thus, for each task the mean score was 10.00 and the standard deviation was 1.00. Since the three tasks were being used to measure a common construct, communication accuracy, it was decided that a K-R 20 estimate of internal consistency would be the best description of the common variance in the three tasks. Considering each task as an item in the overall measure, the K-R 20 estimate of internal consistency was .72.

## Components of Accurate Communications

In addition to measuring communication accuracy and demonstrating its consistency across convergent communication tasks, an attempt was also made to identify components which would account for the observed variance in communication accuracy. A modification of the usual analysis

of individual problem-solving tasks was presented in the first section of this report and five components of two-person problem-solving were suggested: (1) definition of the problem, (2) orientation of Knower to Doer's situation, (3) communication of essential information, (4) synthesis of information and formulation of solutions and (5) verification of the solution.

Since the first component could be expected to occur before communication begins and since the fourth component could be performed implicitly by the Doer, it was hypothesized that three components, 2, 3 and 5, would have to occur in the communication between two persons successfully solving a problem. It is not argued that all convergent communications are organized into stages each composed of a single component, but rather that these components would have to occur and perhaps occur frequently during the course of the communication in order for an accurate solution to be obtained.

The three communication tasks used in this research were analyzed and an attempt was made to assess the adequacy of dyads' performance of the three suggested components. A description of the assessments follows.

Orientation of Knower to Doer's situation. The second variation of the model building task was used to assess dyads' performance of this component. In this variation the dyad's task was to complete the Doer's partial model so that it matched the Knower's complete model. It was expected that communication would begin with the Knower's finding out which portion of the model the Doer had completed. The specific means for assessing the adequacy of orientation was devised by comparing adult and children communications on the second variation of the model building

task. The adult communications began with an extensive orientation of the Knower to the Doer's partial model. The orientation component was easily identified and its termination could be characterized as the point at which (1) the Knower acknowledged understanding of what part of the model his partner held; (2) speech shifted from a description-questioning mode to a direction-giving mode and (3) the Doer began adding pieces to his partial model.

The orientation component was not so regularly formed in the children's communications. In some cases orientation appeared just as in the adult communications. In others, the communication began with the description-questioning mode of speech but shifted to direction-giving and building without or before the Knower acknowledged understanding the Doer's partial model. Other child dyads began building immediately with no orientation.

Scores were assigned as follows:

1. No orientation. Immediate building, no acknowledgement of understanding, no shift of speech mode.

2. Incomplete orientation. Shift of speech mode but building without or before acknowledgement of understanding.

3. Complete orientation. Acknowledgement of understanding, shift of speech mode and building co-occurring.

Children's third and fourth model building communications were scored and the sum of the two scores was used as a measure of the extent to which the dyad oriented the Knower to the Doer's situation.

Communication of essential information. The picture identification task was constructed so that the correct picture differed from the incorrect pictures on various combinations of four attributes. Thus, the essential information necessary to obtain a correct solution in these

subtasks is comprised of the four distinguishing attributes. The communications were scored according to the presence of explicit encodings of this information. In one subtask the score could range from 0 (no distinguishing attribute communicated) to 4 (all distinguishing attributes communicated). Since the arrays of pictures did not involve all possible combinations of the four distinguishing attributes, it was sometimes possible to make the correct identification knowing only two or three of them. Therefore, if the dyad communicated less than four distinguishing attributes but still had sufficient information to make the correct choice, the dyad was given a score of 4. All ten subtasks were scored and the sum was used as a measure of the dyad's communication of essential information.

Verification of the solution. Unfortunately none of the tasks observed in this study of communication accuracy provide an unambiguous way to assess the extent to which dyads verify their solutions. A task is needed which requires a more complex solution. For example, a more difficult version of the picture identification task, i.e., one with more varying attributes, might be expected to elicit a distinct verification component in which the Doer must check his choice against the Knower's model of the correct solution. The tasks used in this investigation, however, involved rather simple solutions which could be verified concurrently with the presentation of information. For purpose of this exploratory analysis, the map tracing task was used to provide a crude estimate of this component.

The map task differed from the other two tasks in the way the information was distributed between the Knower and Doer. In this task it would have been possible for the dyad to execute a correct solution even if the Doer were not permitted to speak. Both members of the dyad were

given copies of the same stimulus material (the map) and, in addition, the Knower was given the correct solution (the route). It was assumed, therefore, that most of the Doer's communication consisted of verifying his execution of the solution presented by the Knower. Thus, the proportion of the total verbal output emitted by the Doer was used as an estimate of the extent to which the dyad verified its solutions.

The sources of ambiguity or error in this measure should be pointed out, however, First, although the Doer may be primarily concerned with verifying his execution, the actual words he utters may have multiple functions. For example a simple utterance such as "yeah" may have simultaneous functions: it may serve to signal that the Doer has completed a step in the solution successfully, it may actively request the Knower to continue, it may assent to the Knower's use of a particular term and it may signal that the Doer is still "available for interaction" (Schegloff, 1968). These multiple functions illustrate the difficulties in assuming that number of words used represents amount of verification. A second source of error lies in the fact that the quality of the Knower's presentation of information, which was not controlled, would be expected to greatly affect the amount of verification required by the Doer and decrease the relationship between the percentage of TVO emitted by the Doer and communication accuracy. Despite these problems, the verification component is somewhat represented by the speech of the Doer and it seemed to be the best measure available in these tasks. Hence, it was used and its relationship to measures of communication accuracy is presented.

Each of the three components of communication - orientation of Knower, communication of essential information and verification of solution -

was assessed in only one task and the assessments were independent of the measures of communication accuracy. In order to test the relevance of these components to the general construct of communication accuracy, the correlations of each component with the combined standard accuracy score were computed. All correlations were positive and significant. As further evidence of the generality of the relationships, the correlations of the components with the accuracy scores for each task were also computed. The correlation coefficients are presented in Table 4.

TABLE 4

Correlation of Communication Components

and Communication Accuracy

| | Picture Task | Model Task | Map Task | Combined Accuracy |
|---|---|---|---|---|
| Orientation of Knower | .26* | .33* | .50** | .41** |
| Communication of Essential Information | .66** | .35* | .42** | .59** |
| Verification of Solution | .14 | .18 | .47** | .28* |

*$p < .05$
**$p < .01$

The relationships presented in Table 4 support the approach to studying communication accuracy proposed here. Both the orientation and communication of essential information components are significantly correlated with the accuracy scores in all three tasks and with the combined accuracy score. The measure of the verification component is positively related to accuracy in all three tasks and significantly related to the

combined accuracy score but the observed relationships are small and less convincing. Given the consistent direction of the correlations and the strength of the results with the other components, it seems that a likely explanation for these weaker results is the problems previously mentioned with the measurement of the verification component. The fact that the success of a dyad's performance in a component observed in one task can be used to predict accuracy in other convergent communications is further support for the assumption that there is a class of communications in which accuracy is largely facilitated by common factors.

The three identified components are not independent factors but each does have some unique relationship to accuracy. The partial correlations of the three components with the combined accuracy score are .26, .56 and .16 for the orientation, communication of essential information and verification components, respectively. Using all three components to predict the combined communication accuracy scores results in a multiple R of .66. In other words 44% of the variance in accuracy can be accounted for by these measures of the three components.

The results of this analysis of communication accuracy in convergent communication tasks are encouraging in that they suggest there may be common factors which facilitate accuracy in a broad category of practical communications situations. The post hoc analysis of components presented here, however, is only a first step toward identifying determinants of accurate communication which could be reasonably incorporated into language arts instruction. Further research is necessary to examine these components and confirm their relationship to communication accuracy and then to determine whether instructional procedures designed to teach students to perform the identified components actually facilitate communication accuracy.

Student Characteristics and Communication Accuracy

In a previous report (Baldwin, McFarlane & Garvey, 1970), SES and racial differences in communication accuracy were presented using observations made with the picture identification task. These data showed that the middle-class students were significantly more accurate than lower-class students and that the white students were significantly more accurate than Negro students. No effects associated with sex were observed. Since that investigation, the measure of communication accuracy has been considerably improved and the extent to which those previously observed findings generalize to other communication tasks can be examined.

The data used for this examination include the same data presented in the previous report plus additional observations on 43 of the original 48 dyads. In order to examine the effects associated with SES, race and sex in all of the tasks, a 2x2x2x3 repeated measures analysis of variance for unequal n's was performed on the standardized accuracy scores.[1] The results of that analysis include only one significant main effect, SES. The middle SES fifth graders were significantly more accurate than the low SES fifth graders across all three tasks ($F = 12.58$, d.f. 1,35, $p < .01$). Again, there was no significant main effect nor any significant interaction effects associated with sex.

The race effect observed in the picture identification task, and previously reported, was not replicated in the other two tasks. In this

[1]Standardizing the accuracy scores on the three tasks precluded a main effect for task differences. The three task means were contrived to be the same. Therefore the degrees of freedom which would normally be associated with a task main effect were subtracted from the total degrees of freedom in the design.

analysis there was no significant main effect for race but rather, a significant race by task interaction. Using the procedure for post hoc comparisons proposed by Marascuilo and Levin (1970), the significant interaction was attributed to two complex interaction effects. The race differences on the picture identification task were greater than expected given the joint main effects of race and task, and the race differences on the map tracing task were smaller than expected. While there is not enough evidence available concerning racial differences in cognitive and language performance to account for this inconsistant performance across the three tasks, the results are simply reported as evidence that for the population of subjects sampled in this research, there is no direct relationship between race and communication accuracy.

The observed social class differences in communication accuracy are consistent with other observations on the communication of socially disadvantaged children (Cowan, 1967; Heider, et al., 1968; Krauss & Rotter, 1968). The differences observed in these data, however, can be more specifically accounted for by two of the components of communication identified in this research. The middle SES children were more successful than low SES children in orienting the Knower to the Doer's situation and in communicating the essential information. Point biserial correlations of SES and performance of these components were .26 and .55 respectively ($n = 48$, $p < .05$).

Although the sample of students was selected to include a limited range of IQ scores (Kuhlmann-Anderson IQ scores ranged from 85 to 115), relationships between these scores and the measures of communication accuracy were observed in the data and thus can be used to examine a question about the relationship between cognitive ability and

communication accuracy. In general, it would be expected that IQ would be directly related to performance on communication tasks since many cognitive skills are involved, but there is some question about whether the lower, the higher or the mean IQ of a dyad is the best predictor of communication accuracy. Mehrabian and Reed (1968) hypothesized that the degree of accuracy would be determined by the lower level of cognitive ability in the dyad. It is also conceivable, however, that the member with greater cognitive ability could be the more effective member in determining the accuracy of communication. When interaction is permitted between the dyad members the brighter member of the dyad can assist his partner in such ways as asking for specific information, re-encoding ambiguous utterances or suggesting different approaches for analyzing the problem. He can influence the continuation of the communication until a satisfactory solution is achieved.

The relationship between IQ scores and communication accuracy observed in this study was analyzed in order to examine this question. The correlations of communication accuracy scores with the lower, the higher and the mean IQ of the dyad are presented in Table 5. The results, showing that the IQ's of both dyad members are related to the degree of accuracy they achieve, do not seem to support the hypothesis set forth by Mehrabian and Reed.

TABLE 5

Correlations of Low, High and Mean Dyad IQ

with Communication Accuracy

| | N | Low IQ | High IQ | $\bar{x}$ IQ |
|---|---|---|---|---|
| Picture Identification | 48 | .34 | .22 | .30 |
| Model Building | 48 | .25 | .38 | .36 |
| Map Tracing | 48 | .39 | .47 | .48 |
| Combined Accuracy Score | 43 | .35 | .32 | .38 |

These data were not intended to be a test of the Mehrabian and Reed hypothesis, however, and there are problems with using them in this way. First of all, the accuracy scores used in this research are based on the result of an entire communication which includes considerable interaction between the dyad members. This score is not a direct measure of the construct of communication accuracy proposed by Mehrabian and Reed, which is defined as the accurate decoding of another's encoding. It is likely that in a simple, one-utterance communication the lower level of cognitive ability in the dyad would largely determine the degree of communication accuracy. In a more complex task, however, involving much interaction, the relationship between the two members' cognitive abilities and communication accuracy would change. The operational definitions of communication accuracy included in the Mehrabian and Reed review, however, suggest that the construct they define would also be expected to determine accuracy in such complex communications as those examined here. Such discrepancies in predicted relationships reassert the point made earlier,

that the construct of communication accuracy will be more successfully defined by restricting it to a specified class of communications.

## Summary and Conclusions

In order to study communication accuracy and to begin to identify its determinants, a type of problem-solving communication was defined in which communication accuracy was expected to be facilitated by common factors. Three tasks were developed which represented this class of communications and which permitted the assessment of communication accuracy, and 48 dyads of fifth-grade children were observed performing these tasks. As predicted, the degree of accuracy achieved by dyads in these communications was consistant across the three tasks. The K-R 20 estimate of inter-task consistency was .72. As further evidence of a general construct of communication accuracy, an attempt was made to identify components of the communications which could account for the degree of accuracy observed in the three tasks. A task analysis, similar to a usual analysis of individual problem-solving behavior, resulted in the identification of three components which would have to be included in a successful problem-solving communication. These were: (1) orientation of one member to the other's point of view, (2) communication of essential information and (3) verification of the problem's solution. Measures for describing the adequacy of a dyad's performance of these components were derived and correlated with the observed accuracy scores. Each component correlated significantly with communication accuracy, and the three components combined accounted for 44% of the observed variance in the communication accuracy scores. These

results were interpreted as support for the hypothesis that there is a class of communications in which accuracy is largely facilitated by common factors.

The measure of communication accuracy was then used to describe differences associated with characteristics of the observed students. Dyads of middle-class children were significantly more accurate than dyads of lower-class children and these differences could be partially explained by their performance of the first two components described above. For the observed sample, there were no consistent differences in accuracy associated with the racial characteristics of the students and no significant differences associated with sex. The relationship of the IQ's of the dyad members and communication accuracy was also examined. It was found, contrary to a hypothesis proposed by Mehrabian and Reed (1968), that communication accuracy was as strongly related to the higher IQ of the dyad as to the lower IQ.

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Appendix A

Social Status Questionnaires

Children's Questionnaire (attached to a letter sent to parents)

1. Child's Name_____

2. Father's occupation_____

   Mother's occupation_____

   OR

   Guardian's occupation_____

3. Number of people living in the house where this child lives_____

4. At home, does this child talk more, less or about the same as other children?

   MORE_____LESS_____SAME_____

_____has my permission to take part in the language study at Hamilton Elementary School.

_____

Parent's signature

Adult's Questionnaire

(your name is not required)

FAMILY HISTORY QUESTIONNAIRE

1. Your present age_____

2. Are you living with your family? (circle one)

   yes during vacation not at all

   Answer the following questions about your family as it was when you were 16 years old.

I. Family Members

   1. Father other male guardian none (underline one)

   2. Mother other female guardian none (underline one)

   3. Number of brothers and sisters living at home (include yourself)____

II. Occupation

   1. Father's (or male guardian's) occupation_____

   2. Mother's (or female guardian's) occupation_____

   3. If you were self-supporting at that time give your occupation

      _____

III. Education

   1. Father's (or male guardian's) years of formal education completed (circle one)

      1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 more

      grade school high school college

   2. Mother's (or female guardian's) years of formal education completed (circle one)

      1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 more

      grade school high school college

## Appendix B

## Experimental Tasks

### Task I: Picture Identification

Child Instructions:

Now you are going to play a different game. In this game, you will have to act as a team if you want to win.

Here are the rules:

One member of the team will get one single picture. The other member of the team will receive a group of pictures. Only one of the pictures in the group is exactly like the single picture. The team's job is to find out which two pictures are exactly alike. The way you find out which two pictures are alike is up to you. You can both ask each other any questions you want to, and you can take as long as you want to. The only thing you can't do is to look at each other's pictures. When you are both sure you know which two pictures are exactly alike, the person with the group of pictures will point out the picture in his group exactly like your single picture. At the end of the game I will tell you how many correct choices the team made.

Any questions?

Adult Instructions:

The first task is a game in which you will work as a team.

Here are the rules:

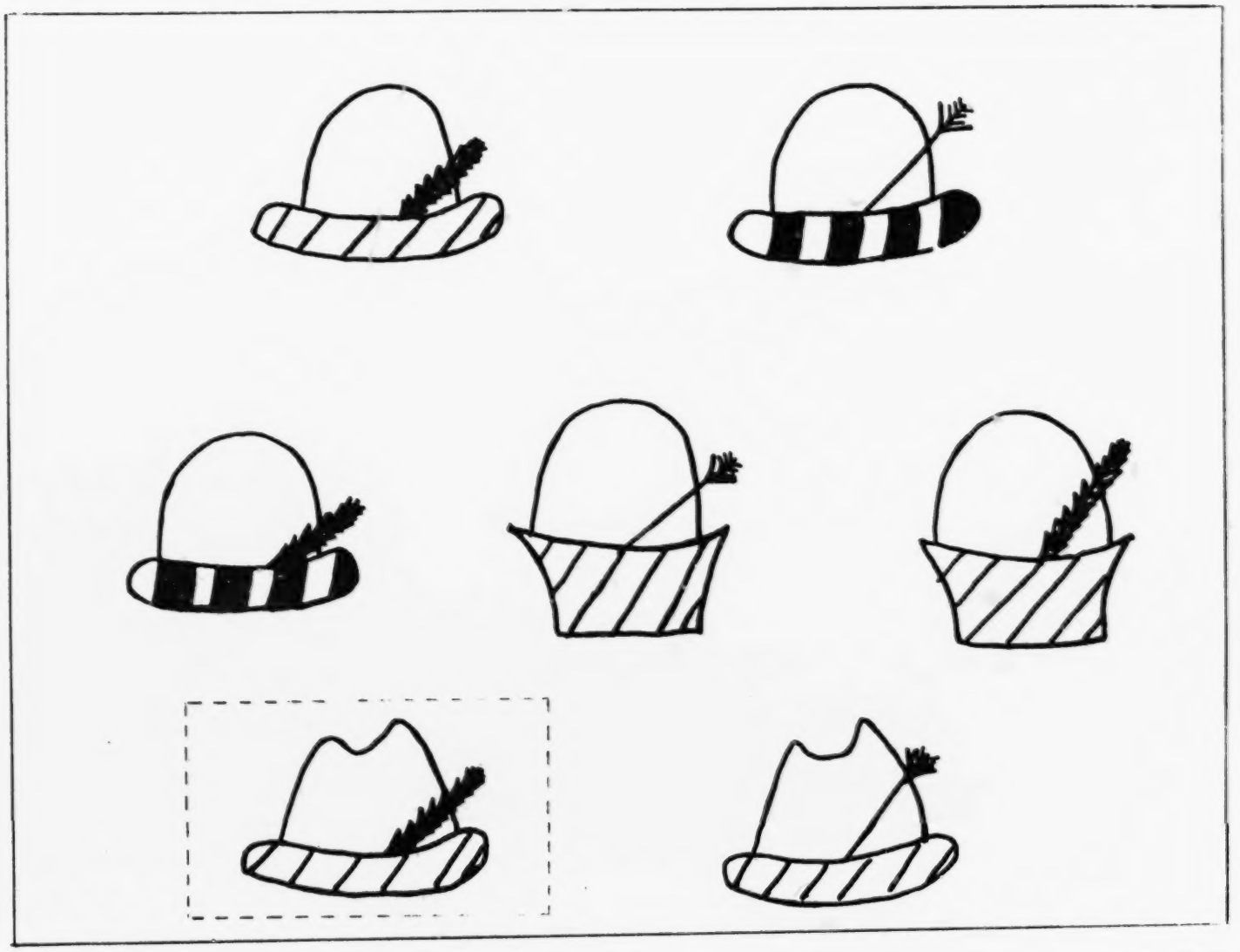
One member of the team will get one single picture. The other member

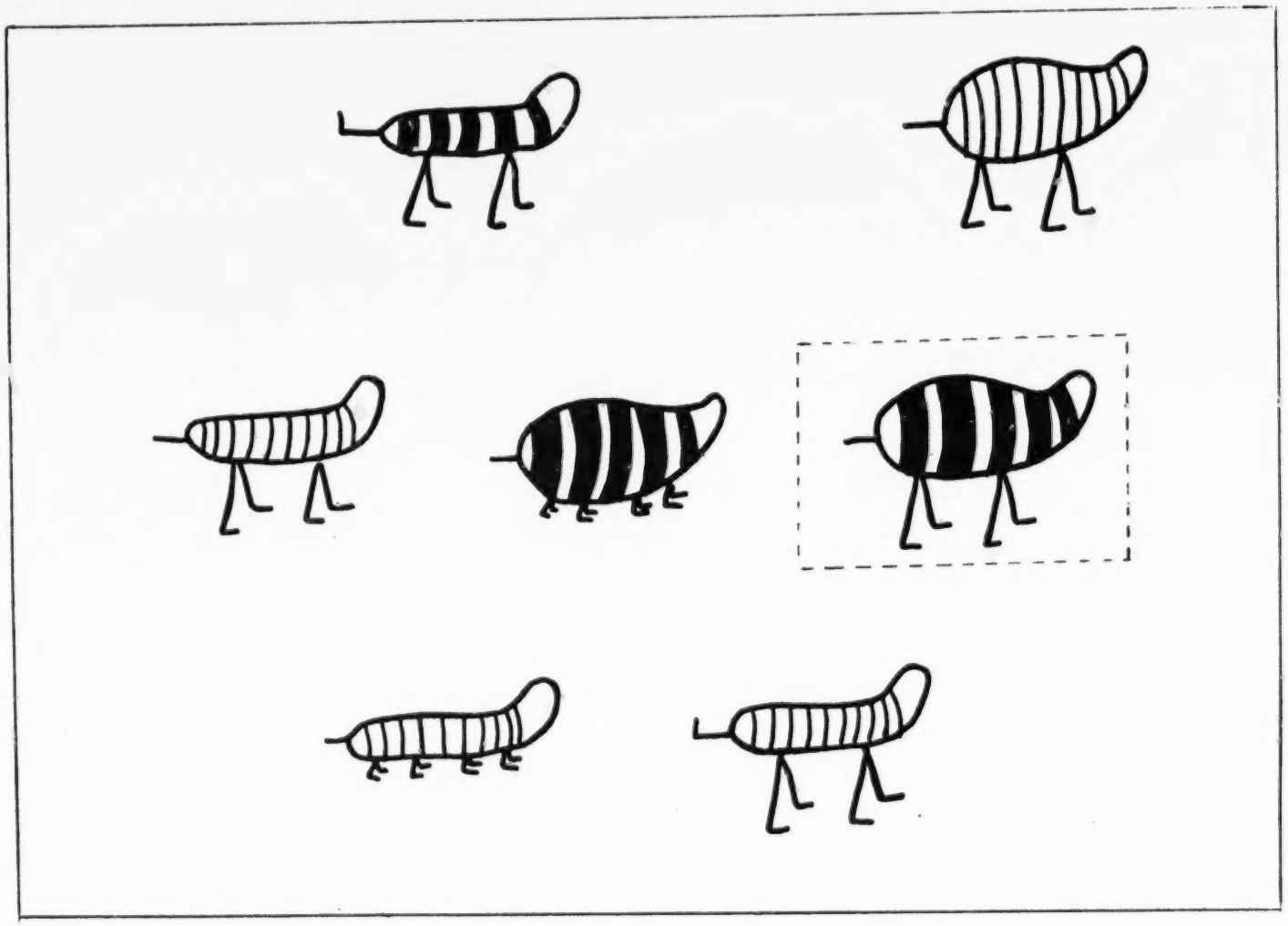
will receive a group of pictures. One and only one of the pictures in the group is exactly the same as the single picture. The team's task is to find out which picture in the group is the same as the single picture. You can both ask each other any questions you like and take as long as you want. You can't look at each other's pictures but you can talk about them. When you are both sure you know which two pictures are the same, the person with the group will point out to me the picture in his group which is the same as his partner's single picture. I will tell you how many correct choices you made at the end of the game.

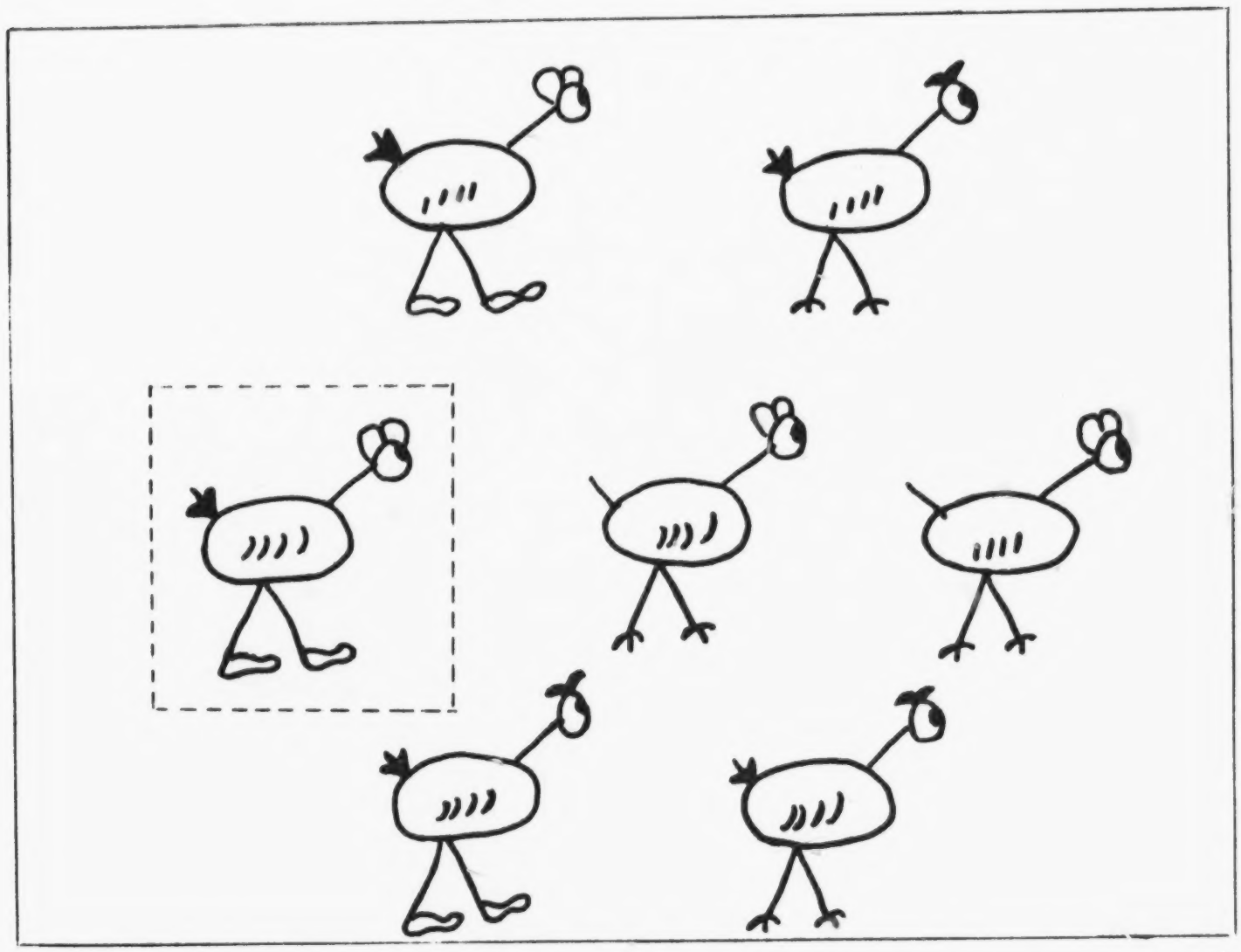
Any questions?

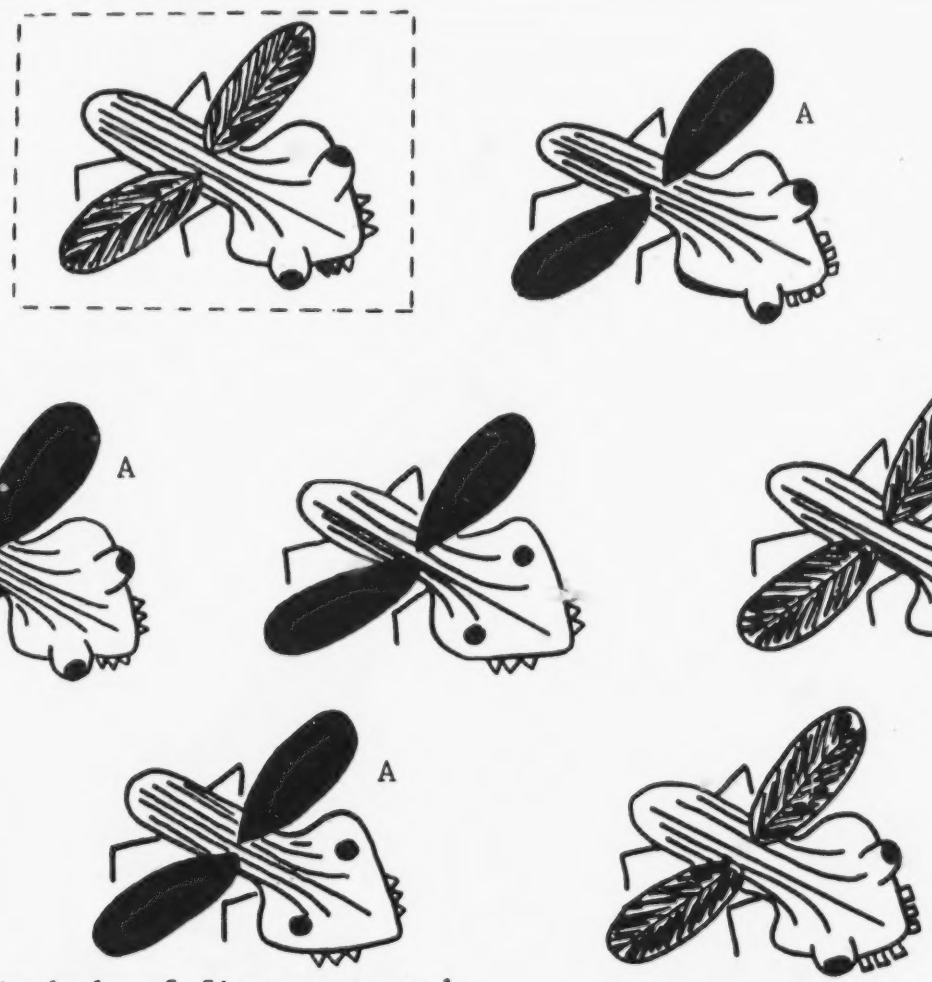
Pictures

The ten groups of pictures used in the picture task are presented on the following five pages. Each group includes the correct figure and six distracting alternatives. For the readers' convenience, the correct figures have been enclosed with dotted lines. Also, letters and footnotes have been used to indicate where color was used as a distinguishing attribute.

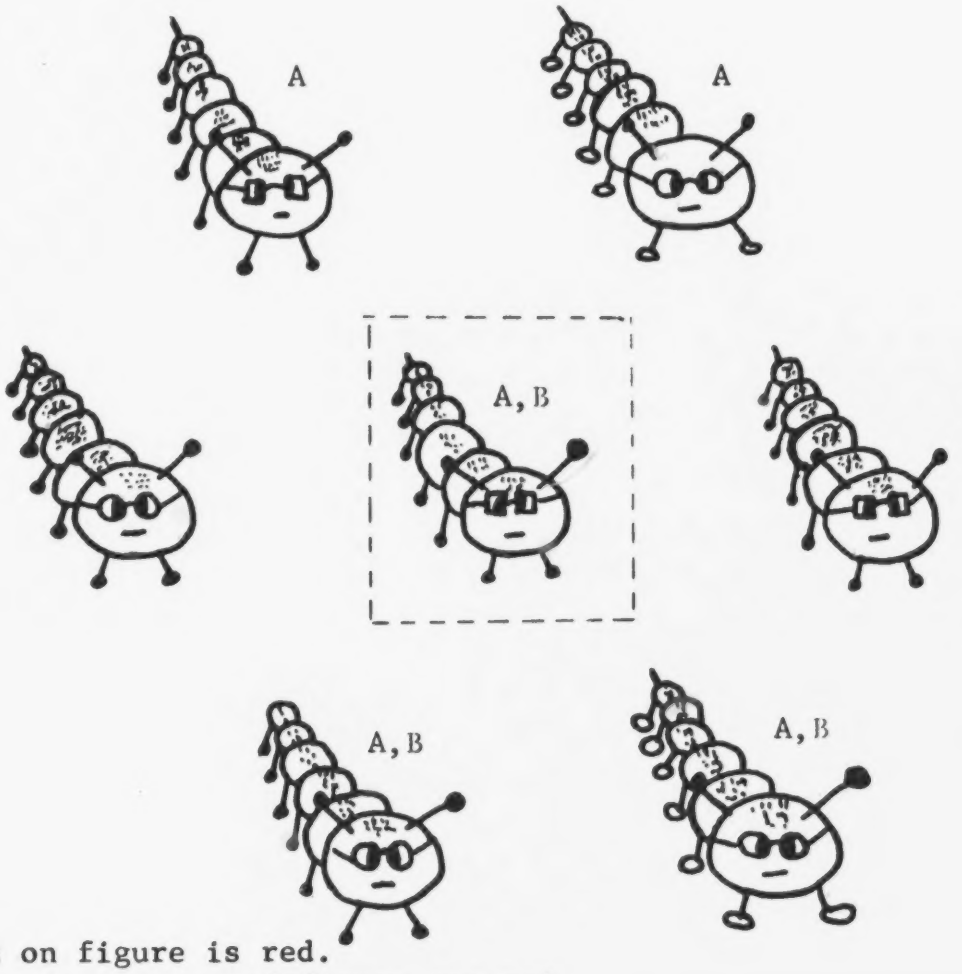




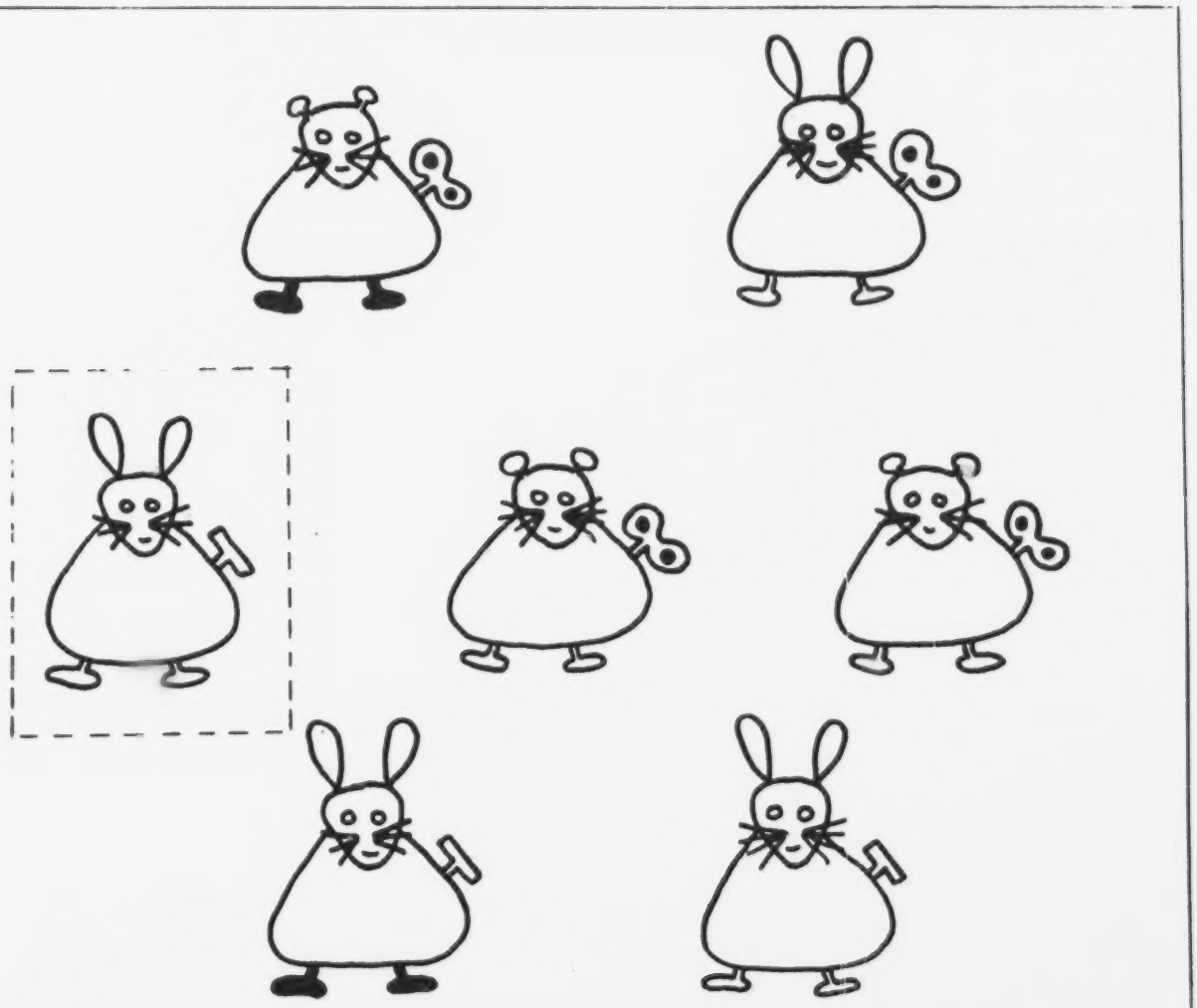


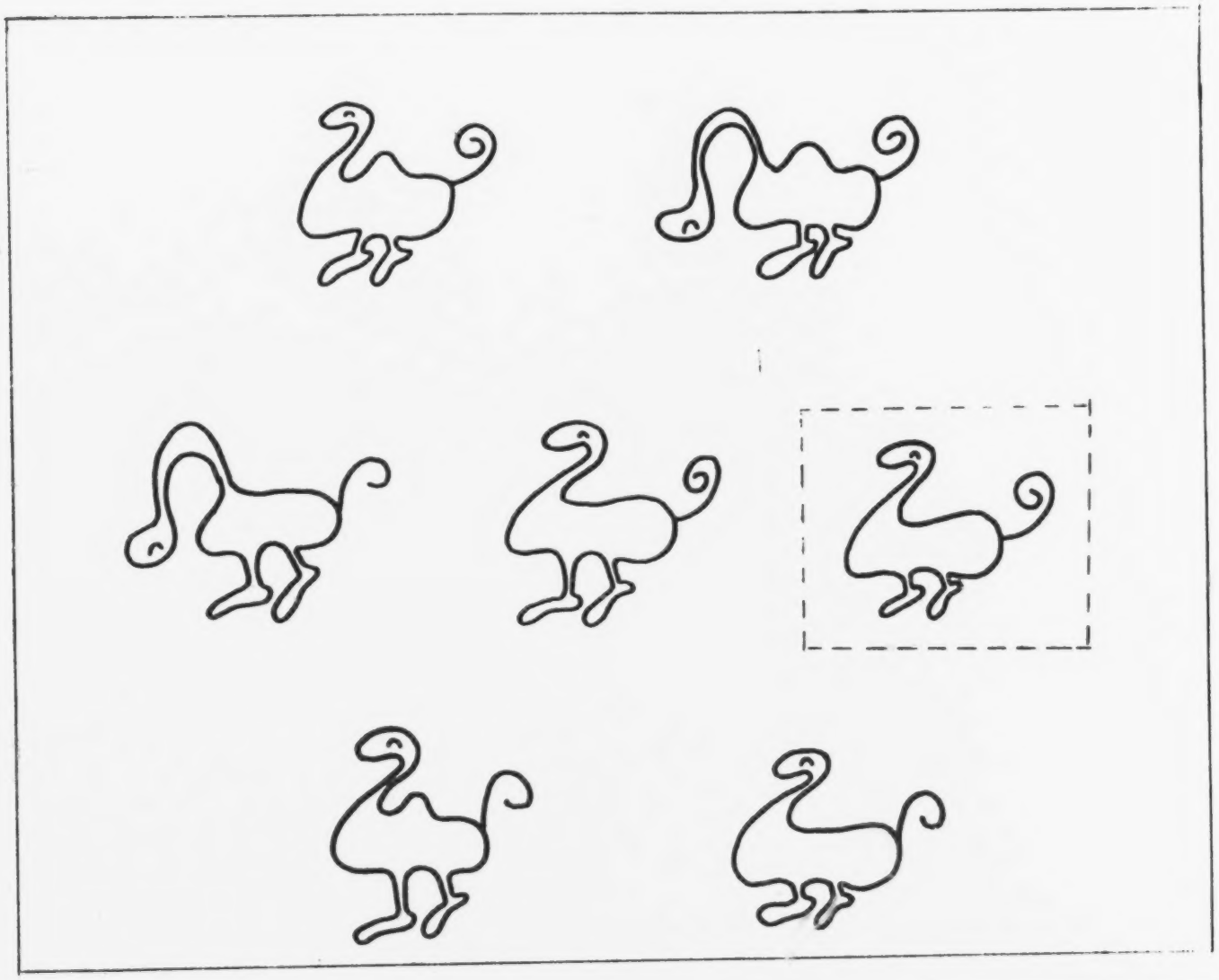


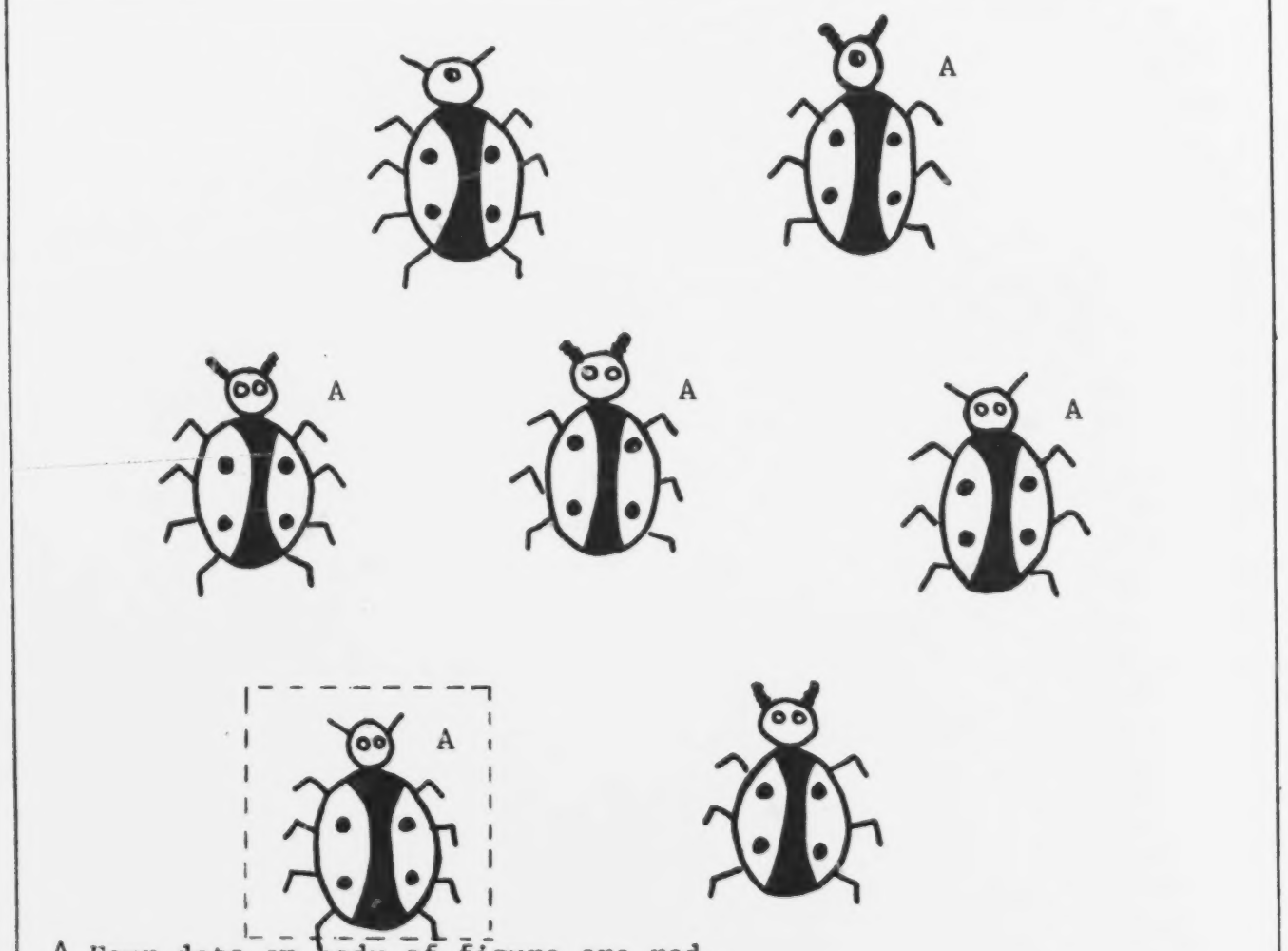

A Lines in body of figure are red.



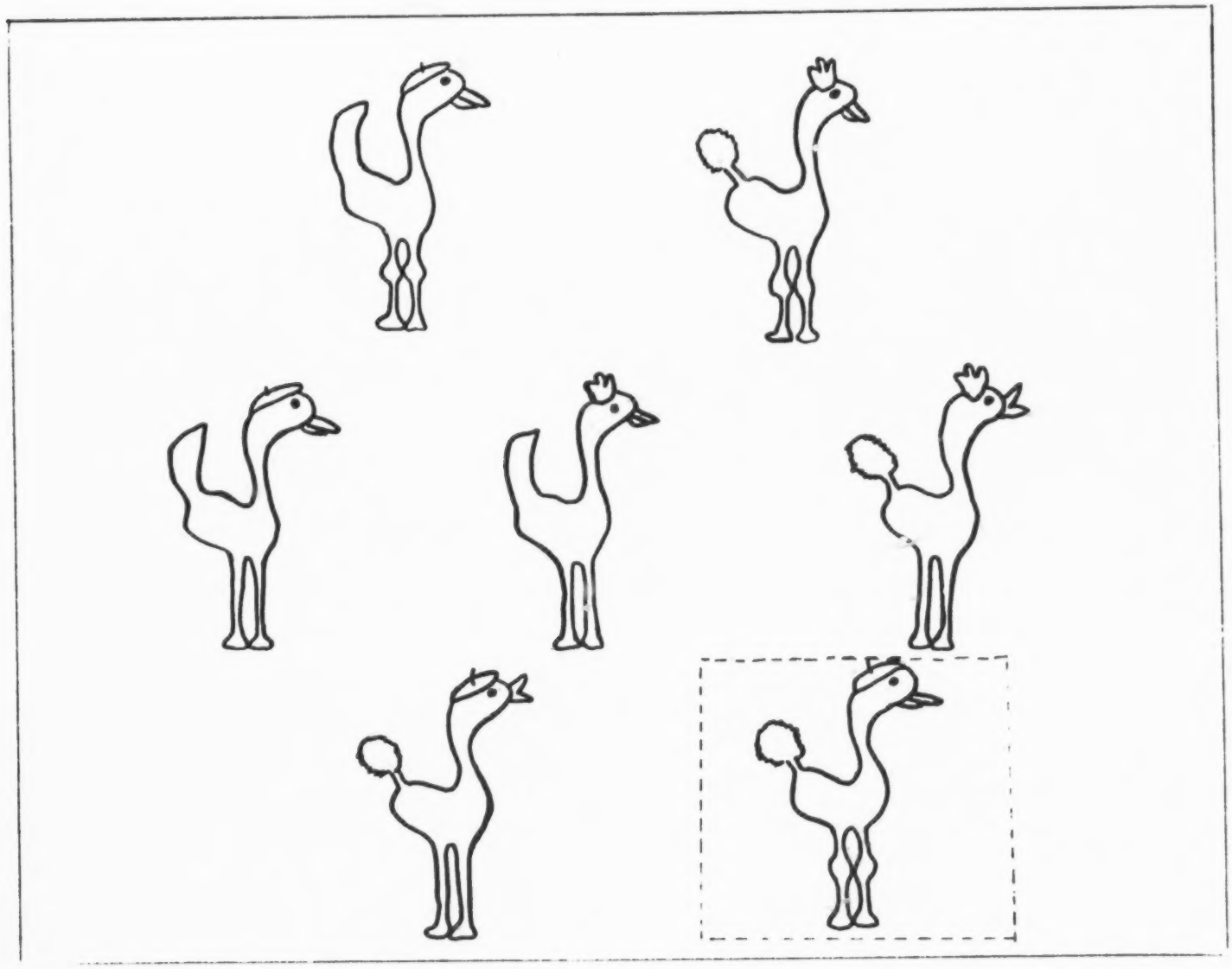

A Fuzz on figure is red.
B Tips of antennae of figure are red.

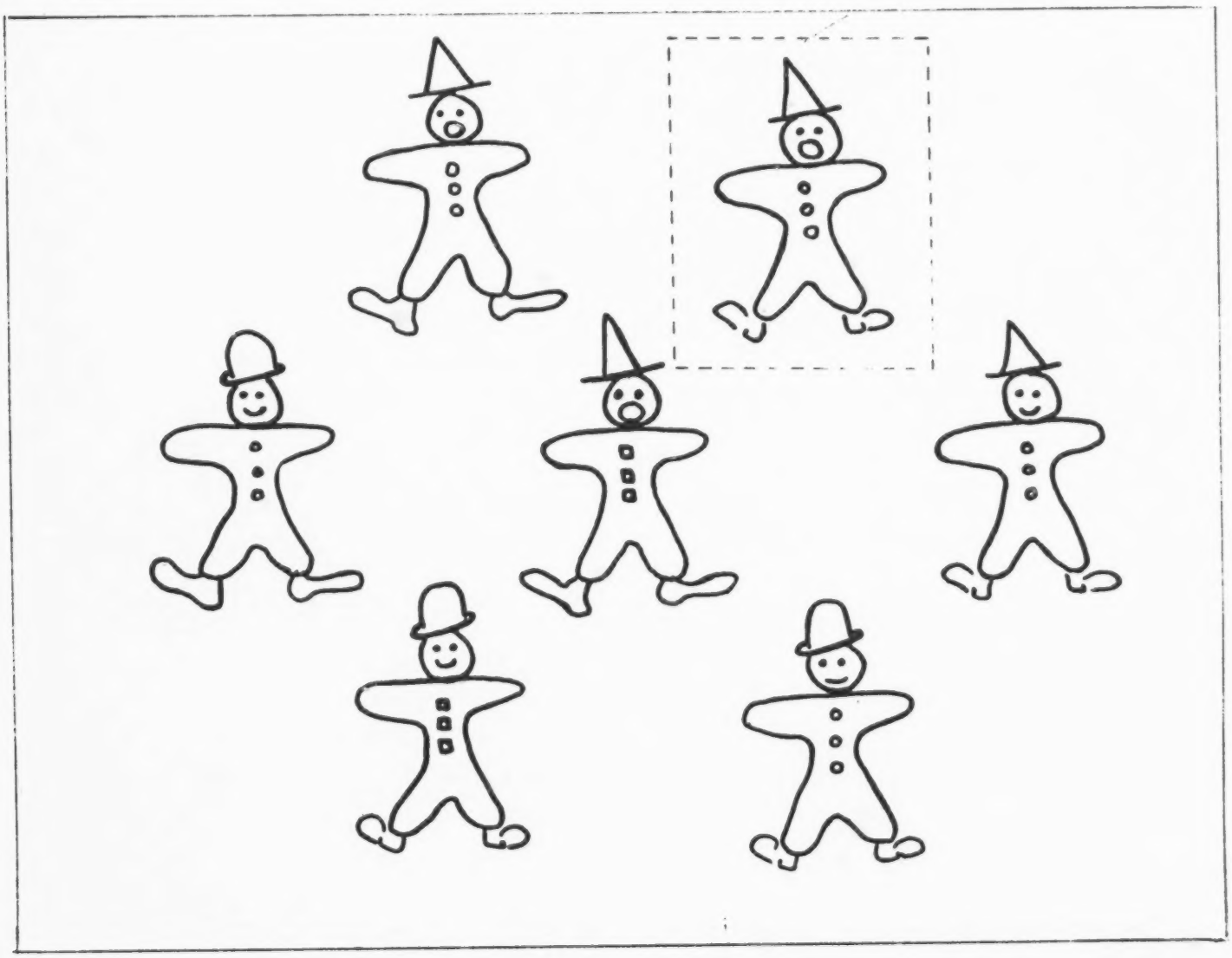







A Four dots on body of figure are red.





## Task II: Model Building

Child Instructions:

The first game you are going to play is a model building game. You are going to be building models of molecules. You will be using pieces that look like this. (Show kit.) They go together in lots of different ways. Here is a simple model. (Build NaCl.) Here's one that's a little bigger. (Build $CH_4$.) Each one is a different size and shape. I'll give __A__ a model and __B__ will get the box of pieces. __B__, you have to find out what your partner's model looks like and build it with these pieces. (Repetition) —> Again, the rules are that you can't talk to me and you can't look at what your partner is doing, but you can say anything you want to each other. __B__, when you have finished building the model and you both think it's a good copy of __A__'s model, tell me and I'll pick it up.

Okay, fine. Now for the second one, __B__ will get the model and __A__ gets the pieces. Your job is to find out from __B__ how to build the model.

Fine, this time we'll change things a little bit. __A__ will get the model but __B__ will get part of the model already built. This time your job is to find out how to complete building the model that __A__ has.

Okay, now for the last model, __B__ will get the model and __A__ gets part of the model. Your job is to finish building the model.

Adult Instructions:

Now, you are going to be building models of molecules. You will be using pieces that look like this. (Show kit.) They can be assembled in lots of different ways. Here is a simple model. (Build NaCl.) Here's one that's a little bigger. (Build $CH_4$.) Each one is a different size and shape. I'll give __A__ a model and __B__ will get the box of pieces. __B__, you have to find out what your partner's model looks like and build it with these pieces. Again, the rules are that you can't talk to me and you can't look at what your partner is doing but you can say anything you want to each other. __B__ when you have finished building the model and you both think it's a good copy of __A__'s model, tell me and I'll pick it up.

Okay, fine. Now for the second one, __B__ will get the model and __A__ gets the pieces. (to A) Now you must find out from __B__ how to build the model.

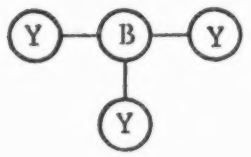
Fine, this time we'll change things a little bit. __A__ will get the model but __B__ will get part of the model already built. This time you must find out how to finish building the model that __A__ has.

Okay, now, for the last model, __B__ will get the complete model and __A__ gets the partial model.

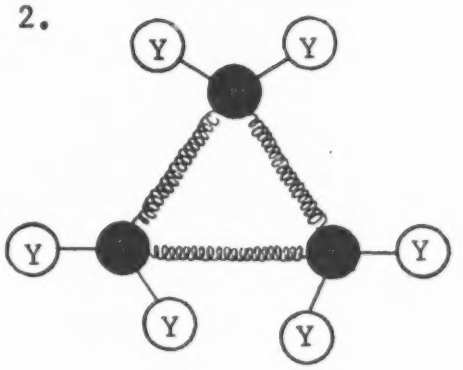
Constructed Models:

The letters inside each ball are the initial letters of the following colors: blue, red, and yellow, representing the actual color used. Filled in balls are black.

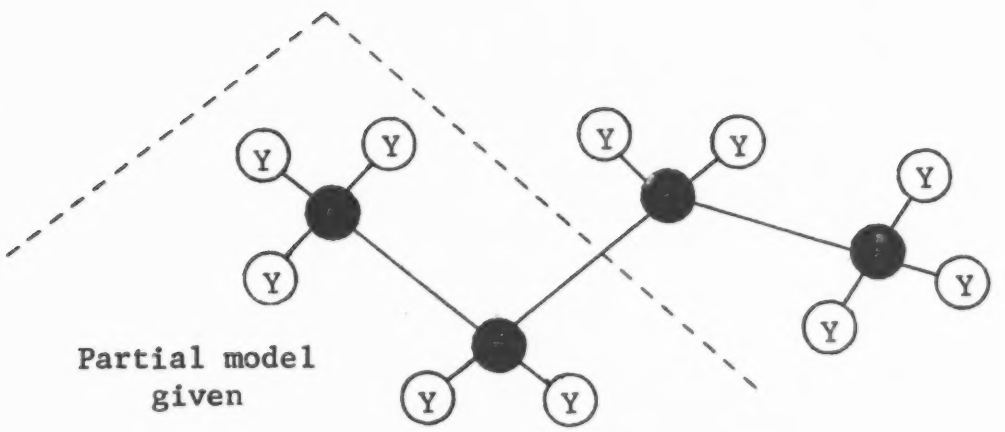
1.



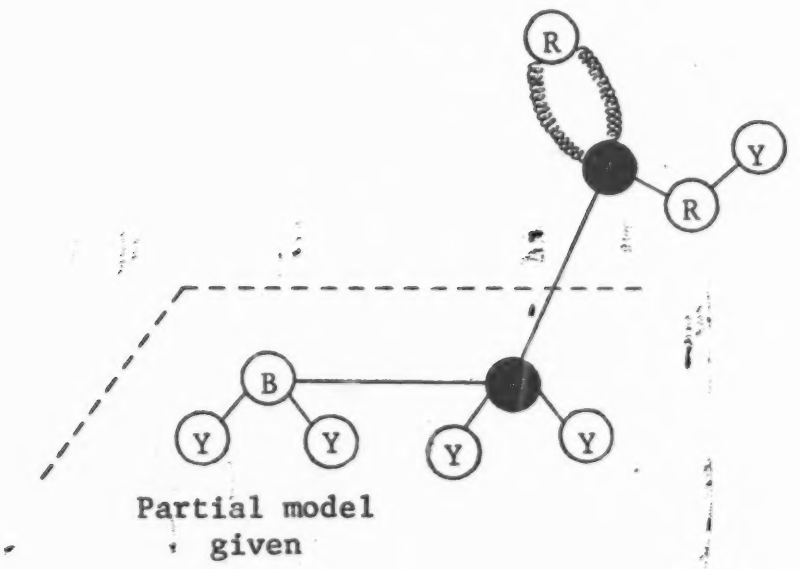

2.




3.




4.



## Task III: Map Tracing

Child Instructions:

Now you are going to play a different game. You both have a map of a town. One of you knows a secret way to get to school because it's marked in red on your map. The other has a black map and a pencil. It's important that you both know the secret path. You must find out what it is. You should mark it on your map with this pencil. The arrow shows you where to begin.

Again, you can't talk to me and you can't look at what your partner is doing but you can say anything you want to each other. When you both think that __B__ has the right path drawn in, give me the maps.

This time you (A) have to find the secret way from the school to the ball park.

Start at the school.

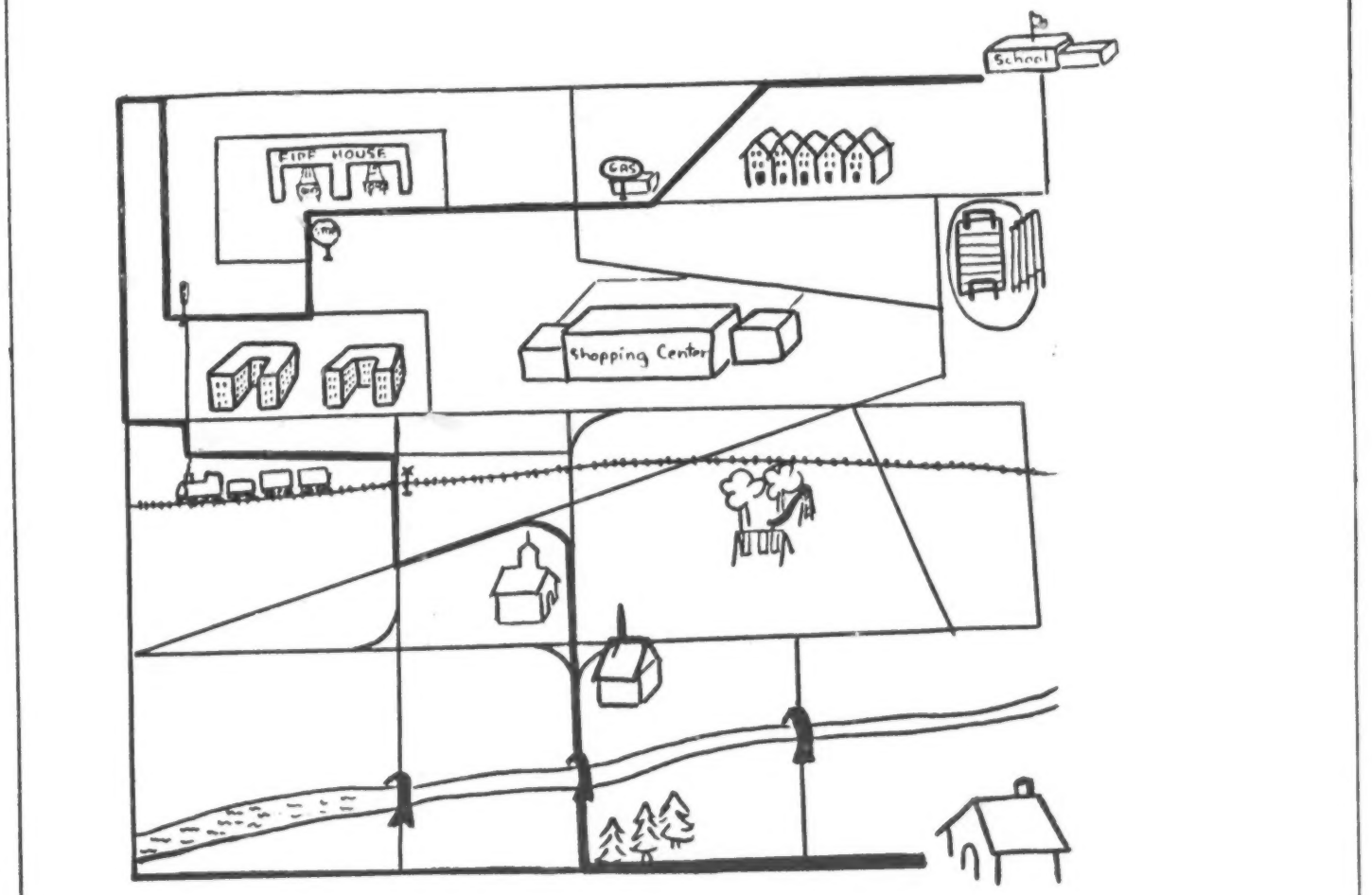
Adult Instructions:

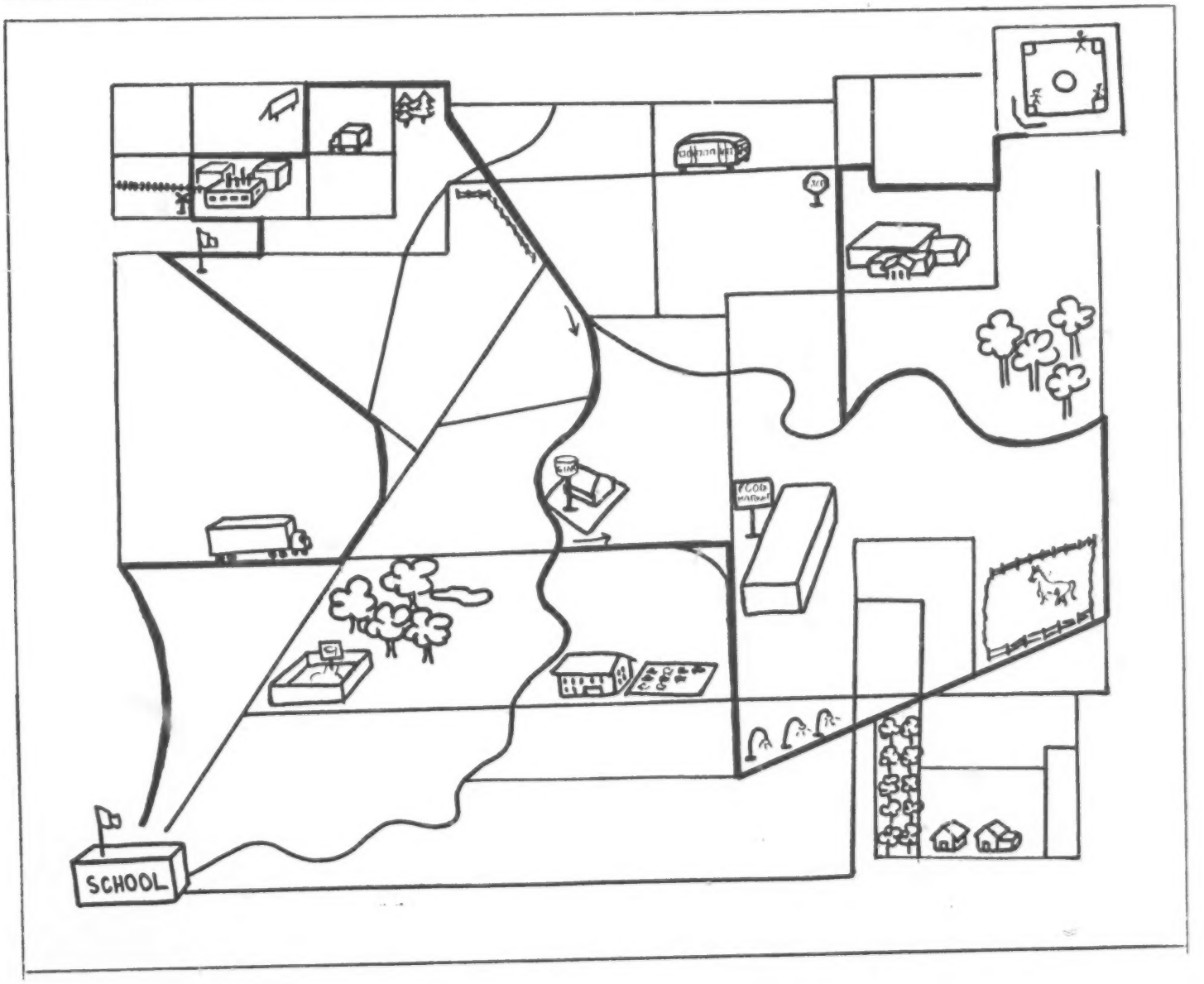
Now you will play a different game. You both have a map of a town. One of you knows a special route to the school. This route is marked in red on your map. (to A) Your partner has a black map and a pencil. (to B) Now you want to find out your friend's special route. You can mark it on your map with this pencil. The arrow shows you where to begin.

Again, you can't talk to me and you can't look at what your partner is doing but you can say anything you want to each other. When you both think that __B__ has the right path drawn in, give me the maps.

This time you (A) want to find a special secret way to get from the school to the ball park.

Start at the school.


School
FIRE HOUSE
GAS
Shopping Center


SCHOOL
FOOD MARKET